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CRYOGENIC SAMPLING OF THE AIRBORNE LASER LABORATORY.(U)  
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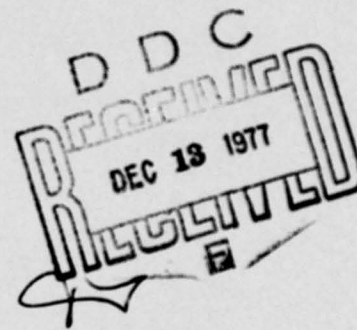
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# CRYOGENIC SAMPLING OF THE AIRBORNE LASER LABORATORY



November 1977

Final Report for Period July-October 1975

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USAF SCHOOL OF AEROSPACE MEDICINE  
Aerospace Medical Division (AFSC)  
Brooks Air Force Base, Texas 78235



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This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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20. ABSTRACT (Continued)

used in the modified KC-135A aircraft cooling system. The low concentration of hydrocarbons observed in the cabin environment indicates that the mass spectrometer will encounter minimal interference under normal operating conditions.

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## CRYOGENIC SAMPLING OF THE AIRBORNE LASER LABORATORY

### INTRODUCTION

Atmospheric baseline data of the cabin of a KC-135A aircraft modified for use as an Airborne Laser Laboratory (ALL) were required for assessing the possible interferences with an onboard Gas Analysis and Detection System (GADS). This device will monitor the aircraft atmosphere and the dynamic laser exhaust ducts in order to advise the crew when onboard gases reach levels of concern. The gases of interest include He (diluent),  $N_2O$  (oxidizer), CO (fuel),  $O_2$  (starter),  $N_2$  (coolant),  $CH_4$  (starter), JP4-JP5-JP8 (aircraft fuel), and  $CBrF_3$  (coolant and fire suppressant) (1).

A cooperative effort was initiated between the School of Aerospace Medicine (USAFSAM) and the Air Force Weapons Laboratory (AFWL/LRP). The approach was similar to that employed in detection of an unknown chemical contamination of DOD Subsistence Trailers (2). Samples were obtained, both on the ground and airborne, with the USAFSAM cryosampler over relatively long periods. The collected samples were analyzed with a coupled gas chromatograph-mass spectrometer-data system (GC-MS-Data).

This report details results of both ground and airborne sampling conducted July-October 1975. The ground phase samples were obtained in a closed aircraft during the late afternoon with minimum activity and in the morning during a more active period associated with preflight requirements. The airborne sample was obtained during a mission.

### EXPERIMENTAL SAMPLING

The aircraft sampled in this study was an early model of the KC-135A built in 1955, which has been modified to become the Airborne Laser Laboratory. The atmosphere to be sampled was drawn from the midline of the aircraft, approximately 5 ft (1.52 m) above the cabin floor and opposite the left wing emergency exit hatch. This sample was concentrated for analysis by the USAFSAM cryosampler (Fig. 1). A flow diagram of the cryogenic sampling system is shown in Figure 2. The atmosphere from which the organic constituents were to be removed was passed serially through a flowmeter at 300  $cm^3$ /minute, sample cylinders maintained at (1) 0°C--ice water bath, (2) -78°C--dry ice bath, (3) -175°C--a liquid nitrogen bath regulated with warm gaseous nitrogen, a flow control valve, and a metal bellows circulation pump. Compounds which have a partial pressure in the gas stream greater than the vapor pressure at the various trap temperatures will be retained (3). Experimentally determined recoveries at 300  $cm^3$ /minute for butane, hexane, and toluene are 67%, 65%, and 91% respectively.

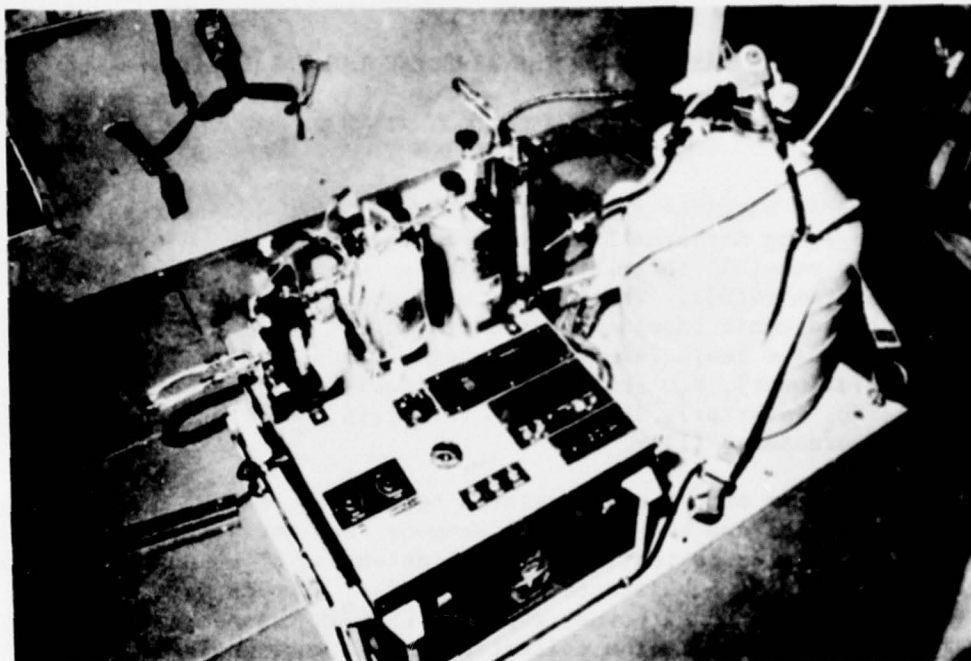


Figure 1. The USAFSAM cryosampler mounted in the aircraft.

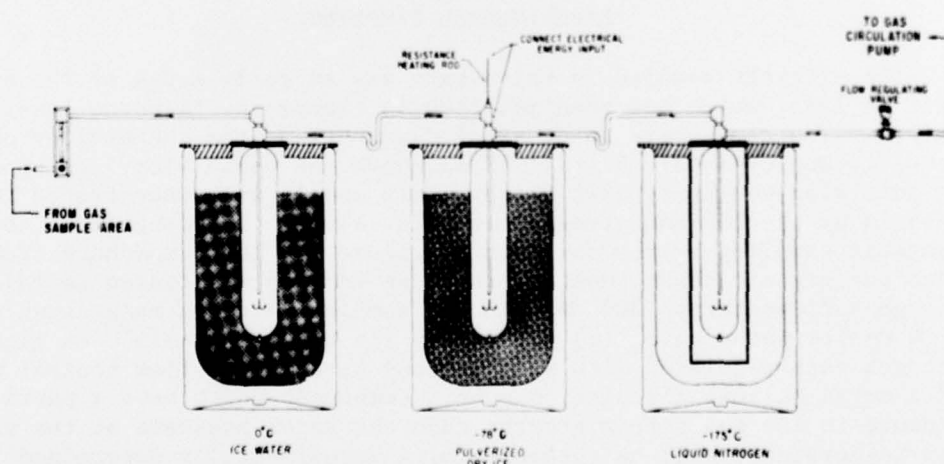


Figure 2. The USAFSAM cryosampler gas flow path.

The conditions of sampling are described in Table 1. The ground level samples were obtained with the aircraft parked. Sample 105 was obtained 1425-1600 hours with the aircraft doors closed. Various ground maintenance activity was in progress with few disturbances in the aircraft. Sample 108 was obtained 0835-1115 hours. There was increased activity in the aircraft. The doors were opened frequently, resulting in increased ventilation.

TABLE 1. SAMPLE CONDITIONS

Sample number	Type	Initial ambient temperature	Flow rate (l/min)	Time of sample (min)	Volume collected (liters)
Sample 105	Ground level	27.4	.3	105.0	31.50
Sample 108	Ground level	23.6	.3	160.0	48.00
Sample 106	Airborne	22.0	.3	268.2	80.46

#### ANALYSIS

Analyses of the samples were accomplished with a gas chromatograph (Varian Model 1400)-mass spectrometer (DuPont Model 21-491)-data system (Dupont Model 21-094)(Fig. 3). The gas chromatograph column was 3-m long by 3-mm OD microbore (0.7 mm ID) stainless steel. The column packing was Porapak Q (a polyalkyl styrene) of 100-120 mesh. The column was temperature programmed from -100°C to 250°C at approximately 10°C/minute. The effluent of the gas chromatograph was split with 25% going to a flame ionization detector (FID), and 75% to the mass spectrometer (MS) (Fig. 4). Compound quantitation was obtained by integration of the gas chromatographic FID response (AutoLab IV). A 95 part-per-million hexane standard prepared by Matheson Gas Products was used as a quantitation reference. Compound identification was provided by the MS-Data System using a DuPont Library Search Program (4). The library is based on spectra of 23,879 compounds (5).





Figure 3. Gas chromatograph-mass spectrometer-data system used for analysis.

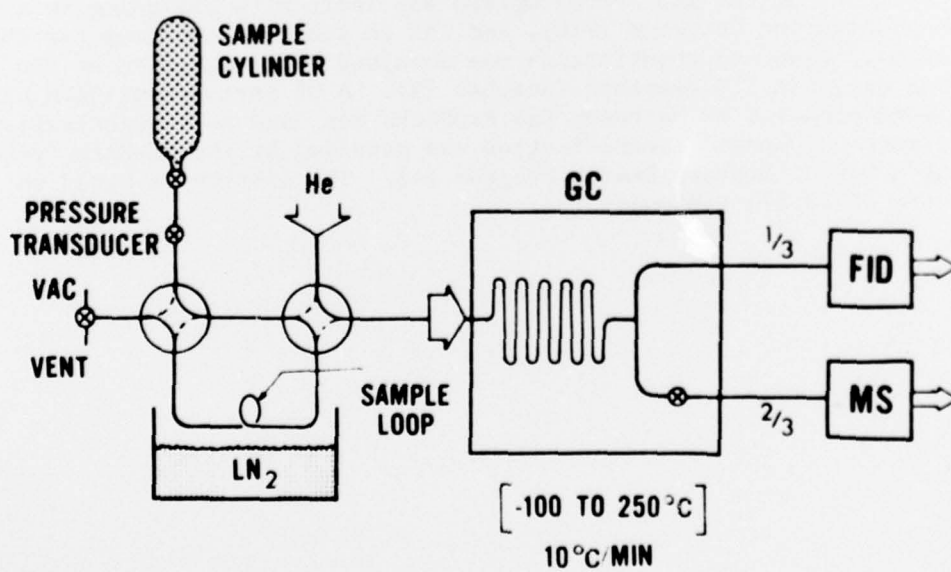


Figure 4. Schematic of analysis system.

## RESULTS AND DISCUSSION

The results of the three analyses of the cryogenically obtained samples are presented in Table 2. The highest concentration of hydrocarbon was associated with the afternoon ground study. This sample was taken at the highest ambient temperature and lowest ventilation rate. The ground sample obtained with the greatest activity and ventilation had a hydrocarbon content equivalent to the airborne sample. There were 58 compounds identified in the three samples. Eight of the compounds were reported in all three samples (ethane, heptane, benzene, toluene, xylene, acetaldehyde, R-12, and R-113). The greatest contribution to the aircraft atmospheric hydrocarbon content was R-12, which is used in the cooling system. R-113 is a common solvent used in cleaning many aircraft systems. The major portion of the hydrocarbons in the paraffin, olefin, naphthene, and aromatic classes occur in turbine engine fuels and are normal constituents of all jet airfield environments. The oxygenated compounds may result from jet engine exhaust, occupancy of the cabin by humans, or offgassing of the aircraft construction materials.

## CONCLUSIONS

The study has indicated that a low level of hydrocarbons was present in the aircraft cabin. The highest compound concentration occurred on a hot afternoon with the aircraft closed. Flight conditions represent essentially the same conditions as those observed at ground level with the aircraft ventilated. The levels of hydrocarbon were sufficiently low to present minimal interference with onboard gas monitoring equipment.

TABLE 2. AIRBORNE LASER LABORATORY ATMOSPHERE SAMPLES (JULY-OCTOBER 1975):  
COMPOUNDS REPORTED BY CHEMICAL CLASS AS PARTS-PER-BILLION HEXANE

Compound	Ground study		Airborne study
	Sample 105	Sample 108	Sample 106
<u>Paraffins</u>			
Ethane	.3	.2	.6
Pentane	1.0		
2-Methylpropane	3.0	2.0	
n-Hexane	1.0	.6	
4-Methyl-1-pentane	2.0		
2,3-Dimethylpentane	7.0	3.0	
n-Heptane	2.0	2.0	.5
2,3,3-Trimethylpentane	3.0		
2,4-Dimethyl-3-ethylpentane	4.0	3.0	
n-Butane		.1	
3,3-Dimethylhexane		3.0	
3-Ethylhexane		5.0	
n-Nonane	6.0	2.0	
3,4-Dimethylhexane			.8
2-Methyl-4-ethylhexane			.4
2,2,3,4-Tetramethylpentane			.8
<u>Olefins</u>			
Ethene	2.0	.5	
Propene	1.0	.2	
2-Methylpropene	2.0	Trace <sup>a</sup>	
1-Pentene	.3		
4-Methyl-1-hexene	.8		
5-Methyl-2-hexene	10.0		
1-Butene		.5	.9
<u>Diolefins</u>			
1,3-Butadiene			.9
Isoprene			4.0
<u>Naphthenes</u>			
Methylcyclopentane	.6	.1	
6,6-Dimethyl fulvene	4.0		
1-Methyl-1-ethylcyclopentane		.5	
Methylcyclohexane			.5
<u>Aromatics</u>			
Benzene	1.0	.7	2.0
Toluene	9.0	4.0	2.0
Xylene	10.0	5.0	5.0

<sup>a</sup>Trace compounds have a concentration less than .05 parts-per-billion.

TABLE 2 (Continued)

Compound	Ground study		Airborne study
	Sample 105	Sample 108	Sample 106
<u>Aldehydes</u>			
Acetaldehyde	8.0	7.0	6.0
Propanal	1.0	1.0	
Butanal	4.0	3.0	
Iso-valeraldehyde	1.0		
2-Ethylbutanal	20.0	3.0	
Hexanal	10.0	2.0	
Heptanal	2.0	4.0	
<u>Alcohols</u>			
2-Ethyl-n-butanol	9.0		
2-Propylheptanol			.8
4-Methyl-1-pentyn-3-ol			.5
<u>Ketones</u>			
2-Propanone	5.0		8.0
2-Pentanone	6.0		
2,3-Pentanedione		2.0	
3-Pentanone		5.0	
4-Methyl-2-pentanone		3.0	
<u>Ethers</u>			
Vinyl methyl ether	2.0		
1,2-Epoxypropane		.1	
<u>Nitrogen-containing</u>			
n-Butyl nitrate	.1		
<u>Halogen-containing</u>			
R-12	100.0	9.0	40.0
1,1,1-Trifluoroacetone	Trace	.1	
R-113	3.0	.8	.1
1-Chloro-3-methylbut-2-ene		.5	
2-Chlorobutane		1.0	
Tert-butyl bromide		.3	
1-Fluorohexane			1.0
<u>Sulfur-containing</u>			
Carbon disulfide	.1	.1	
<u>Unknowns</u>			
	Trace	1.0	6.4
Total hydrocarbons	241.2	75.3	81.2



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